Learning to Write Like Scientists:
English Language Learners' Science Inquiry & Writing Understandings
in Responsive Learning Contexts

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Introduction

A renewed effort to study the benefits of literacy & science inquiry has revealed these two processes to be mutually supportive and more importantly their intersection to result in greater than the sum of their individual effects. The role of text in support of scientific inquiry for example serves the function of not only delivering content, but modeling scientific reasoning (Glynn & Muth, 1994; Palincsar & Magnusson, 2000). Similarly, by writing about science students can clarify their thinking while learning the discourse of science (Rivard, 1994; Rowell, 1997; Shepardson & Britsch, 1997). Yet, this promising pedagogy has thus far not adequately considered how this approach could benefit the fastest growing and in many cases most vulnerable sector of the school-age population-English language learners (ELLs). This paper probes how a set of fourth grade students designated as (ELLs): a) learned to write science reports after culturally and linguistically responsive hands-on science activities and b) how they reflected their understanding of the scientific inquiry model through their writing. These questions are probed in the context of a larger National Science Foundation funded project (Science Instruction for All-SIFA) aimed at better understanding and promoting both science and literacy achievement for culturally and linguistically diverse students.

The Importance of Language and Culture in Learning and Teaching

Successful communication with students is essential to effective teaching. From a constructivist perspective, learning occurs when the students build understanding by integrating prior knowledge with new information. Theoretically, teaching and learning environments that serve students well recognize that students have been constructing knowledge and are continuing to do so, both in and out of school. In the case of students from diverse cultural and linguistic backgrounds, this means building a learning environment that incorporates already constructed knowledge, including their first languages and cultural values, in home and community environments (Garcia, 1999; Tharp & Gallimore, 1988).

How do we as educators begin to understand such a complex set of interactions? The term "constructivist" is an apt one. The constructivist perspective is rooted in the notion that for humans, knowing is a result of continual building and rebuilding. We come to understand a new concept by applying knowledge of previous concepts to the new information we are given. For example, in order to teach negative numbers, a math teacher can use the analogy of digging a hole—the more dirt you take out of the hole, the greater the hole becomes; the more one subtracts from a negative number, the greater the negative number becomes. But a math teacher cannot use this example with children who have no experience digging holes. It won't work. This theory of how the mind works implies that continual revisions (or "renovations," as an architect might say) are to be expected. Therefore, when we organize teaching and learning environments, we must recognize the relevance to our goals of students' previous educational environments.

Embedded in a constructivist approach is the understanding that language and culture, and the values that accompany them, are constructed in both home and community environments. This approach acknowledges that children come to school with constructed knowledge about many things, and points out that children's development and learning are best understood as the interactions of past and present linguistic, socio-cultural, and cognitive constructions. Development and learning are enhanced when they occur in contexts that are socio-culturally, linguistically, and cognitively meaningful for the learner. These meaningful contexts bridge previous "constructions" to present "constructions."

Meaningful contexts for learning have been notoriously inaccessible to children from culturally and linguistically diverse backgrounds, often contributing to their educational vulnerability. The monolithic culture transmitted by US schools in their forms of pedagogy, curricula, instruction, classroom configuration, and language dramatizes the lack of fit between these students and the school experience. The culture of US schools is reflected in such practices as:

- The systematic exclusion of the histories, languages, experiences, and values of students from diverse linguistic and cultural backgrounds from classroom curricula and activities.
- "Tracking," which limits access to academic courses and justifies learning environments that do not foster students' academic development, socialization, or perception of themselves as competent learners and language users.
- A lack of opportunities to engage in developmentally and culturally appropriate learning in ways other than by teacher-led instruction.

Although the cultural norms and language experiences that diverse students bring to the class may differ from those of the mainstream, research indicates that teachers who consider students' home language and cultural experiences:

- provide students with important cognitive and social foundations for learning English;
- produce a positive academic difference (August & Garica, 1988); and
- promote students' participation and positive interpersonal relations in the classroom (Au & Kawakimi, 1994; Trueba & Wright, 1992).

In addition, when teachers treat students' cultural and linguistic knowledge as a resource rather than as a deficit, students are more able to access the school curriculum (Cummins, 2000; Valenzuela, 1999). The more comprehensive the use of their home languages, the greater the potential will be for students from diverse linguistic and cultural backgrounds to be academically successful (Miramontes, Nadeau, & Commins, 1997).

To provide effective instruction for students from diverse backgrounds, teachers can use students' home languages as appropriate to enhance their comprehension of instruction, and encourage students to use their home languages for effective communication (Lee & Fradd, 1998). To establish an instructional environment that builds on students' resources and strengths in classroom instruction, teachers need to incorporate students' cultural experiences at home and in the community, use cultural artifacts and community resources, use culturally relevant examples and analogies drawn from students' lives, and consider instructional topics from the perspectives of multiple cultures. In essence, learning is enhanced when it occurs in contexts that are culturally, linguistically, and cognitively meaningful and relevant to the students (Cole, 1996; Diaz, Moll, & Mehan, 1986; Heath, 1986; Moll, 2001; Scribner & Cole, 1981; Wertsch, 1985). It is through their first languages and home cultures that students create frameworks for new understandings.

Science Learning for Students from Diverse Backgrounds

Students bring to the science classroom ways of looking at the world that are formed by their personal environments (Driver, Asoko, Leac, Mortimer, & Scott, 1994). Students from diverse cultural and linguistic backgrounds have acquired everyday knowledge and primary discourses in their homes and communities, while they also learn science disciplines and discourse in school. To provide effective science instruction, teachers face the challenges to ensure that diverse students, who may have acquired diverse world views and had varied experiences, have access to and opportunities for acquiring the nature of science disciplines as practiced in the science community and school science.

Science, as generally taught in school, has been defined in terms of Western tradition (American Association for the Advancement of Science, 1989, 1993; National Research Council,

1996) and yet tends to be regarded as "culture free" and not as a socially and culturally constructed discipline (Banks, 1993; Peterson & Barnes, 1996). Many assumed that all students would learn science when provided with opportunity. However, critics from a diversity perspective have raised epistemological and pedagogical concerns about the nature of science, learning, and teaching as traditionally defined in the science community and school science. In addition, large-scale standardized test scores in science clearly indicate significant achievement gaps among ethnolinguistic groups. A small body of research currently exists on promoting science learning and achievement with students from culturally and linguistically diverse backgrounds; more is needed if the goal of "science for all" emphasized in current science education reform is to become a reality.

According to science education standards documents (AAAS, 1989, 1993; NRC, 1996), science learning involves a two-part process "to acquire both scientific knowledge of the world and scientific habits of mind at the same time" (AAAS, 1989, p. 190). The development of scientific knowledge involves "knowing" science (i.e., scientific understanding),"doing" science (i.e., scientific inquiry), and "talking" science (i.e., scientific discourse). The cultivation of scientific habits of mind includes scientific values and attitudes, as well as the scientific world view. Because the science practices in US school contexts reflect the thinking of Western society, the norms and values of science are most familiar to students from the mainstream middle-class (Eisenhart, Finkel, & Marion, 1996; Lee & Fradd, 1998).

Science Education Standards (NRC, 1996) — the approaches for enabling students to become independent learners as they acquire knowledge by reflecting, predicting, inferring, and hypothesizing — may pose challenges for many students from different culture and language backgrounds (Casteel & Isom, 1994; Westby, 1995). Limited English language proficiency and diverse cultural perspectives should not prevent diverse students from engaging in meaningful science inquiry or from participating in formal and informal classroom participation. Learning science is dependent on students' ability to comprehend and communicate concepts and understandings (Fradd & Lee, 1998). To promote science learning and achievement for culturally and linguistically diverse students, educators need to develop a pedagogy merging subject-specific and diverse-oriented approaches (Lee, 2002).

Science and Literacy

Though much of the teaching and learning that takes place in science classrooms involves both reading and writing, there has been ambivalence toward considering the role of literacy within the science classroom (Armbruster, 1993; Ebbers, 2002). With several parallels between literacy and science, it could be the case that building the skills in one of these domains facilitates the learning of similar skills in the other domain. For example, such prescriptions from the National Science Education Standards (2000) as learning to make predictions about the natural world based on evidence, could assist young readers use/make evidence-based predictions as a comprehension strategy when they read text. Part of the resistance to focusing on reading and writing in science education is rooted in the premise that science should be 'hands-on' and not focused on the mediums through which these activities are often conducted. This resistance can have particular effects for ELLs whom highly depend on: a) text as a source of linguistic input (Wong-Fillmore & Snow, 2000); and b) writing in English to attain feedback on their language abilities (Cummins, 2002).

With respect to reading in science education, researchers interested in the use of nonfiction genres to promote science practices have identified informational texts as reflecting the various processes of the scientific inquiry model (Ebbers, 2002; Armbruster, 1992; Moss, 1995; Duke & Bennett-Armistead, 2003). Reference readers, field guides, procedural texts and journals all provide students with authentic texts that can be used to understand the natural world while supporting literacy practices, including engaging prior knowledge in enacted literacy/science practices.

For example, Palinscar and Magnusson (2000) found secondhand learning of key science concepts related to light was facilitated by the use of texts when included in the curriculum. Comparing classrooms that read expository text and a scientist notebook text related to reflection and refraction of light, the researchers found both texts to support student learning. The genre of one of the texts, the scientist notebook scaffolded both student and teacher's use of the text in an inquiry fashion by including and drawing attention to such text features as tables, figures and diagrams. Diagrams were used to depict the arrangement of the investigation materials, data in the form of figures to allow students to 'make sense' of the data and tables used to display the multiple ways data can be displayed. Such visual features of texts have been identified as key strategies in assisting ELLs gain access to important concepts since these schematic representations provide conceptual clarity for information that is abstract and difficult to grasp (Echevarria, Vogt, & Short, 2004). Similar mutual benefits to science and reading have been found by other researchers

(Gaskins & Guthrie, 1994; Romance & Vitale, 1992, Schmidt, 1999; Padilla, Muth & Lund 1991; Keys, 1994; Casteel & Isom, 1994).

Writing in the science classroom has shown similar promise in enhancing content learning (Glynn & Muth, 1994; Gaskins, Guthrie, Satlow, Ostertag, Six, Byrne, & Connor, 1994; Yockey, 2001; Rowell, 1997). As with reading, writing tasks must be tailored to achieve specific goals of the curriculum allowing students for authentic writing opportunities about deep conceptual understandings rather than simply recording findings (Rivard, 1994). One area of research about the writing that takes place in science classrooms has centered around children's science journals. This practice has been found to provide teachers with an opportunity to gain access to and assess changes in student science learning (Dana Lorsbach, Hook, & Briscoe, 1991) and single out any science misconceptions (Shepardson & Britsch, 1997). Writing also serves a reflective goal for students, as they examine their thought organization and reinforce or augment their interpretations of the science activity at hand (Glynn & Muth, 1994). Though several studies exploring the profit of integrating writing and science lend evidence to positive results stemming from this synergy, some studies indicate little improvement in science achievement (Smith, 1991; Wotring, 1981).

Such expository writings as note taking, explaining, summarizing and analyzing have likewise shown promise in science learning (Lee & Fradd, 1998). Laidlaw, Skok, & Mclaughlin (1993) deduced from their investigation of fifth and sixth grade student science achievement that note-taking improved science outcomes as students learned to take notes about their investigations as scientists do. Writing too benefits from the context of science instruction as students are expected to (re)present their scientific understandings and their associations through learned grammar and discourse strategies specific to the content (Lemke, 1990). Assuring that writing is constructive rather than rote requires students to engage their prior knowledge, have a real-world context for writing, and models science process skills.

Though reading and writing can play an influential role in the learning of science for mainstream students, ELLs face the challenge of learning English in addition to science concepts and literacy. This requires instruction to not only underscore key science understandings, the literacy needed to attain and communicate these understandings but also teach the type of English needed to function in the discourse of science-*academic English*. The National Science Teachers Association (1991), Halliday (1989), Wong-Fillmore & Snow, (2000) identified element of the type of English needed by ELLs to thrive academically in mainstream classrooms.

The National Science Teachers Association (1991) suggest that in science academic English functions to formulate hypotheses, propose alternative solutions, describe, classify, infer, interpret data, predict, generalize and communicate findings, all heavily dependent on literacy. Halliday (1989) suggests that the language of science can be characterized by a restricted number of linguistic features including technical vocabulary and such syntactic elements as passive constructions. Wong-Fillmore and Snow (2000) classify the following as key elements of academic English that students should be able to perform in the content areas:

1. Recognize ungrammatical and infelicitous usage in written language, and make necessary corrections to texts in grammar, punctuation and capitalization;

2. Use grammatical devices for combining sentences into concise and more effective new ones and use various devices to combine sentences into coherent and cohesive texts;

3. Compose and write an extended, reasoned text which is well developed and supported with evidence and details.

The synergy between literacy and science appears to present ELLs with an opportunity to acquire academic language proficiencies. Yet, this is also a risky proposition if instruction does not demystify the type of language needed to function in the discourse of science (Scarcella, 2003), the use of conditionals (e.g., if…then…) when reporting findings from their investigations, for example. Knowledge of such constructions is equally essential to comprehend scientific understandings when reading science texts. This paper hopes to identify if ELLs benefit from science instruction that has embedded within opportunities to write about their hands-on science experiences. By benefits we refer to an increased understanding of the scientific inquiry process and writing of scientific reports. These elements are assessed through the *Authentic Science Inquiry Literacy Assessment System* (ASILAS) where students conduct hands-on science activities then write a report about their findings. The assessment system has several built-in scaffolds such as opportunities to share results with others, plan their writing with the use of a graphic organizer and assistance from the teacher as needed leading up to the independent writing task.

Science Instruction for All

The Science Instruction for All project implements an instructional intervention to promote achievement and equity in science and literacy, particularly focusing on science inquiry, for linguistically and culturally students. This intervention, in the form of a thematic science curriculum uses household materials for conducting scientific inquiry activities and is a medium for examining language, literacy, and collaborative interactions in the classroom. The research framework's foci are on responsive instructional engagement that encourages students to construct and reconstruct meaning and to seek reinterpretations and augmentations to past knowledge regarding literacy and science within compatible and nurturing schooling contexts. Diversity is perceived and acted on as a resource for teaching and learning instead of a problem.

The research uses a longitudinal design with teachers for a 3.5-year period and students for a 3-year period. Two levels of intervention were offered: (a) teacher professional development provided by the research and (b) instructional process provided by the teachers for their students.

Research Setting and Participants

The study is conducted in an urban school district that enrolls approximately 58,000 students. Of these students, 31% are Chinese, 21% Latino, 15% African American, and 10% White (not Hispanic). District-wide, 56% of elementary students are in free or reduced lunch programs, and 29% are designated as limited English proficient, primarily speaking Spanish and Chinese in the home. This study focuses primarily on those students designated-English language learners

During the academic year 2002-2003, 4 elementary schools, representing different linguistic and cultural groups of students, participated in the project. Two of the participating schools have bilingual programs in which students receive content instruction in both English and designated languages. Data collection for this study took place in the two bilingual classrooms.

Table 1 summarizes the key features of the participating school. Two teachers from the pool of 6 fourth grade teachers involved in the larger study were selected for this smaller-scale research. Their selection was not random, but purposeful since these were the two teachers with classrooms that were made up of English language learners. All teacher participation was voluntary. Writing samples from a total of 40 students, 20 per class were used to evaluate their understanding of the scientific inquiry model and science report writing. Students' language proficiencies varied from early intermediate stages to early advance.

Table 1. Key School Features

Bilingual Program	Ethnicity (Major groups)	SES (free & reduced lunch)	Limited English Proficient (LEP)
Spanish/English Chinese/English	67% Latino 19% Chinese	85%	72%

Instructional Intervention

The instructional intervention focuses on two units each for 4th graders (the Water Cycle and Weather). Before implementing each science unit, the teachers met with the UC-Berkeley team to learn how to implement the units from teachers who had taught the units before. The implementation of the science unit took place, on average, two to three hours a week for the majority of classrooms. Project personnel visited each classroom once a week to provide instructional support. All teachers were provided with complete sets of materials, including teachers' guides, copies of student books, and science supplies. All participating teachers completed implementation of their respective units.

Research Instrument and Data Collection

To analyze how ELLs in the primary grades learned to conduct science inquiry with literacy as the medium through which they expressed this development, a partnership between classroom teachers and researchers from the SIFA research group led to a co-constructed assessment, Authentic Science Inquiry Literacy Assessment System (ASILAS), that lend itself to authentically gauge students' science inquiry and literacy development not in isolation of each other, but at their intersection.

Two ASILAS writing tasks accompanied each unit taught at the fourth grade. One of the units comprised of instruction surrounding Water Cycle while the other dealt with the theme Weather. Each of these units was embedded with literacy activities including reading material and opportunities for students to write expository texts. The ASILAS were administered in conjunction with the investigations that students were already a part of in the unit. They were purposely administered in a pre/post manner. This paper will share the findings from 40 fourth grade students' writing which rendered a total of 160 writing samples.

Because the assessment had an explicit goal of creating assessment conditions that required students to think and write authentically like scientists, the ASILAS included a student investigation, group work where a lab book was utilized to "guide children's writing and thinking" (Shepardson & Britsch, 1997), opportunities to share their results and finally an independent writing task. The following Figure 1 more vividly represents the cyclical nature of the ASILAS administration.

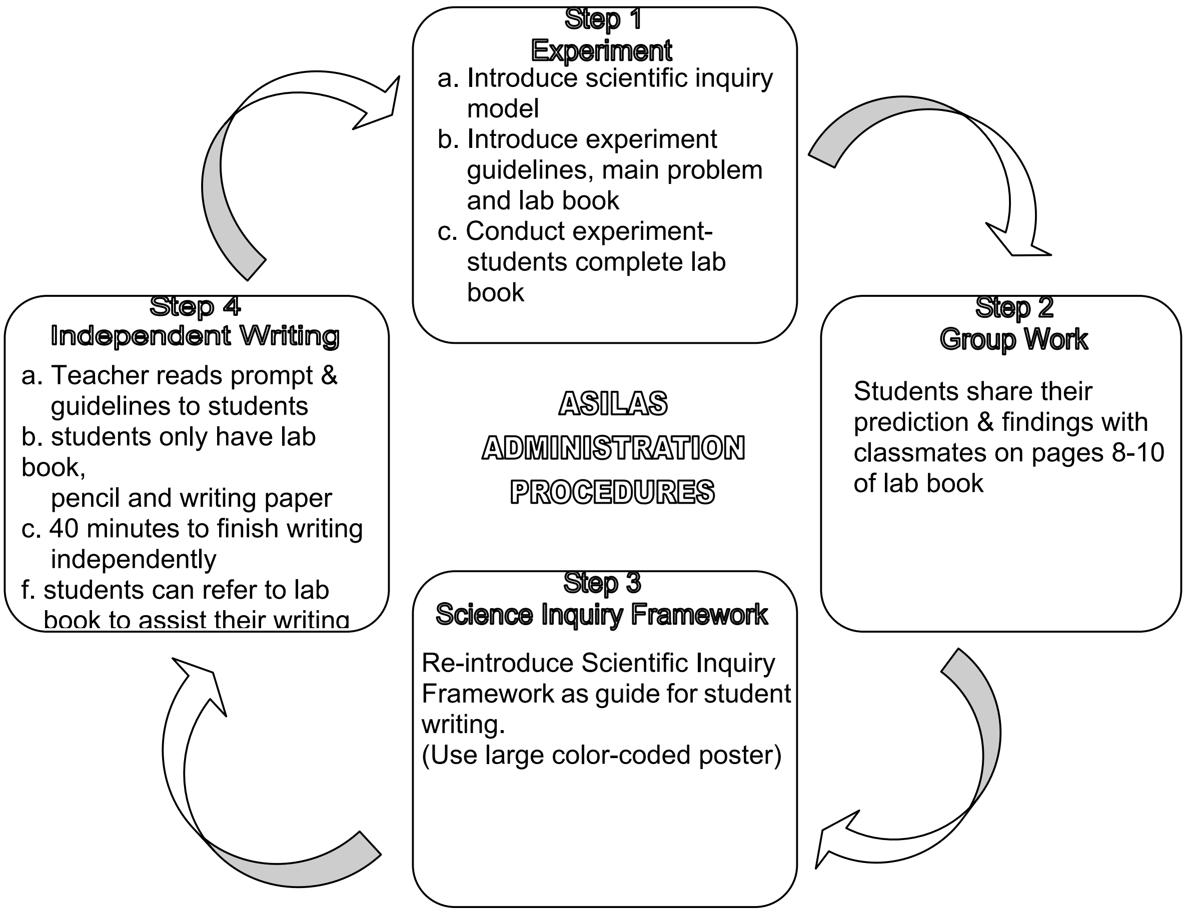

Figure 1. ASILAS Administration

Data Analysis and Results

The research team evaluated each of the writing samples by scoring them according to the ASILAS rubric which contained four categories (Science Inquiry, Organization, Style/Voice, and Conventions). The rubric scaled from a score of one to six and clearly marked state standards at scores of 2 for third grade, 4 for fourth grade and 6 for fifth grade. In other words, at the end of each grade, students' writing should be reaching these scores to be considered as writing at grade level. Before scoring the writing samples, 5 team members were involved in a two-day training on the scoring protocol to assure reliability and validity. Members scored ASILAS writing samples only after obtaining a 90% inter-rater reliability score on 10 student-writing samples.

The ASILAS data collected for the academic year 2002-2003 yielded some interesting results. At the onset of the Water Cycle unit, students in the fourth grade class experienced difficulties writing an expository text based on their investigations. As the following figure illustrates, students were well below grade level when the first ASILAS was administered.

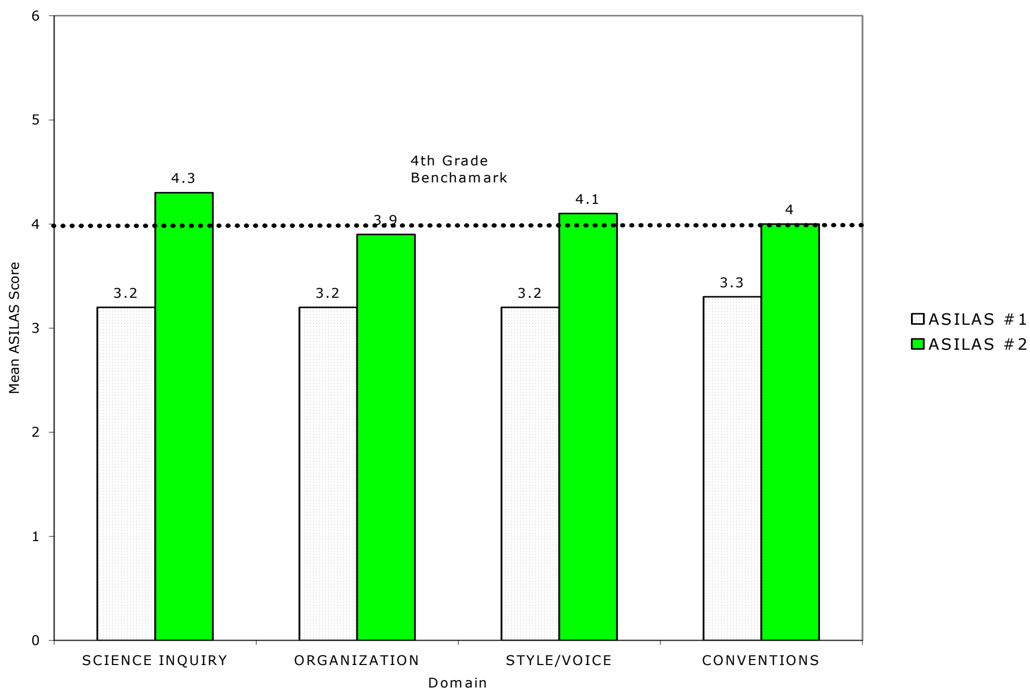

Figure 2. 2002-2003 ASILAS Water Cycle Unit Pre/Post Assessment (n=40)

For ASILAS #1, students' writing somewhat addressed the *Scientific Inquiry* domain of the rubric, which required students to: (a) align their hypothesis with their proposed question, (b) describe the procedures and materials involved in the experiment, and (c) conclude with some results. Initially students listed only partial procedures and either proposed a question to study or a hypothesis, but not both. At the end of the unit and after several practice activities with the scientific inquiry model, students managed to provide descriptions of their materials and procedures, addressed their results in their concluding paragraph, but continued to include either a question or hypothesis in their expository text. Students managed to attain a score of 4.3 on the rubric, a score above the 4th grade benchmark.

The *Organization* domain of the rubric involved paragraph structure and overall cohesiveness of the students' text. Though students included a topic and supporting sentences in their paragraphs, the sequence of the paragraphs was often not logical. Three months later when the second ASILAS was administered, students' writing matured considerably in this domain. Student writing included transition words that connected introductory, supporting and summarizing paragraphs, yet was marked by a tendency to structure these elements in a narrative fashion. This can be attributed to the fact that minimal instruction during the unit dealt with the structure needed in expository texts.

The *Style/Voice* domain addressed issues of sentence structure and the use of science/ descriptive language. Student understandings about using simple and compound sentences and including such terms as hypothesis, investigate and evidence ripened as students encountered these vocabulary items in texts and were required to utilize them in their investigations during the unit. Yet, the sentences were seldom constructed in the passive voice as is common in many science textbooks (Wong-Fillmore & Snow, 2000). Instead, the past tense and active first person was employed, another characteristic of narrative texts.

A common worry of many classroom teachers teaching writing deals with the last domain of the ASILAS rubric *Conventions.* This domain assessed how well students spelled, punctuated and used correct grammar. While initially students managed to spell all high frequency words (e.g., I, am, have) correctly, almost always used appropriate punctuation and capitalization and showed some troubles with using the correct pronoun and/or adverbial forms, by the end of the unit they were more capable of spelling correctly irregular words and demonstrated no difficulties with punctuation or capitalization. Troubles with using conjunctions and correct pronoun continued to plague student papers after the second ASILAS administration.

A similar blue print in scores was found among student papers when the Weather unit was administered during the second semester of the academic year (see Figure 3).

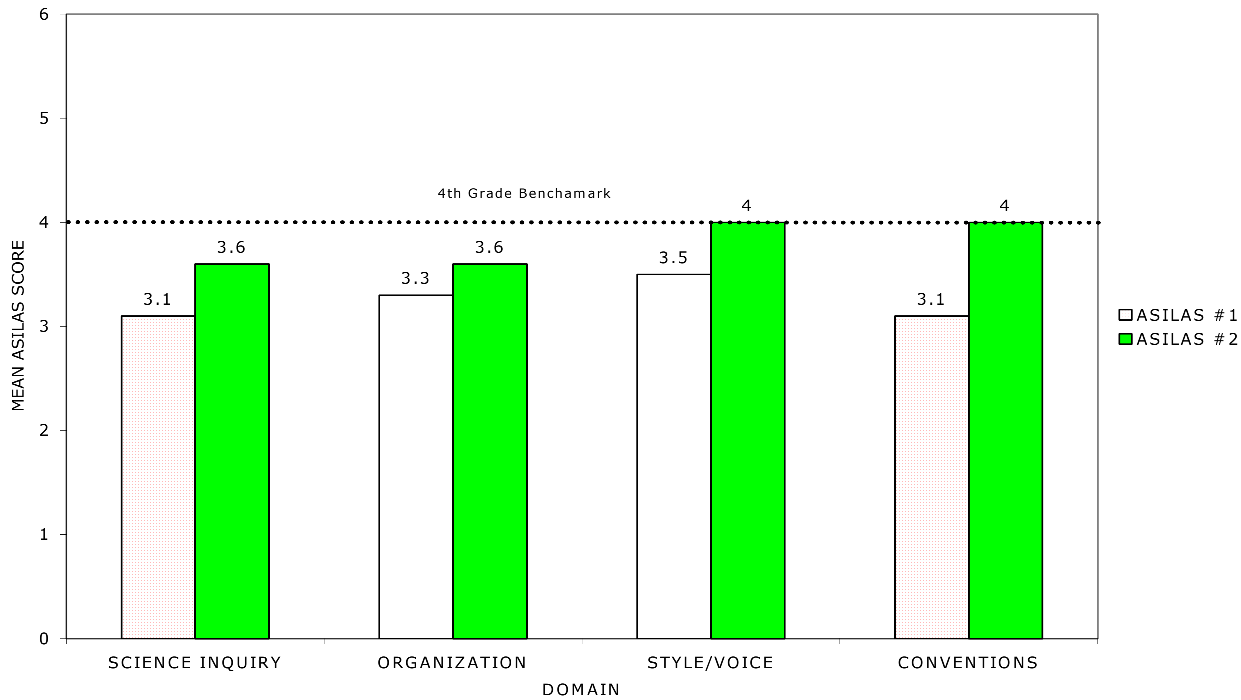

Figure 3. 2002-2003 ASILAS Weather Unit Pre/Post Assessment (N=40)

In comparing the initial scores with those in the previous unit, what is initially observable is that students did not sustain their understandings of the elements found in the four domains of the writing rubric at the onset of the first ASILAS. The long winter break could be responsible for the descent in scores. An alternate plausible purpose for the descent in scores could be that the Weather Unit curriculum was found more demanding than the Water Cycle Unit, making the conceptual understanding of key scientific inquiry knowledge challenging. This latter explanation assumes that students' demonstration of their literacy skills was highly dependent on their understanding of the scientific content material.

Nonetheless, students managed to again demonstrate an increasing understanding of the scientific inquiry framework. Three months after the initial ASILAS was administered, students outlined their experiment nicely, assuring to include a question and hypothesis, procedures and materials and results. This framework was organized in two paragraphs written in a logical sequence with varied sentence structures and science vocabulary. Spelling, punctuation and grammar also matured by the end of the unit. Though students did not reach grade level standards in *Science Inquiry* and *Organization,* they did so in *Style/Voice* and *Conventions.*

To probe the percentage of students that were scoring below, at or above grade level, a holistic score was calculated through attaining a mean among the *Science Inquiry, Organization,* *Style/Voice, Conventions* domains, giving equal weight to each. These scores were then measured up to the fourth grade benchmark of four. This yielded percentages that represented the proportion of students reaching or falling below grade level expectations for each pair of ASILAS administrations. As is evident by Figure 4, more students were writing and understanding the scientific inquiry process after experiencing the embedded literacy and science curriculum in both the *Water Cycle* and *Weather* units than at the onset of the intervention.

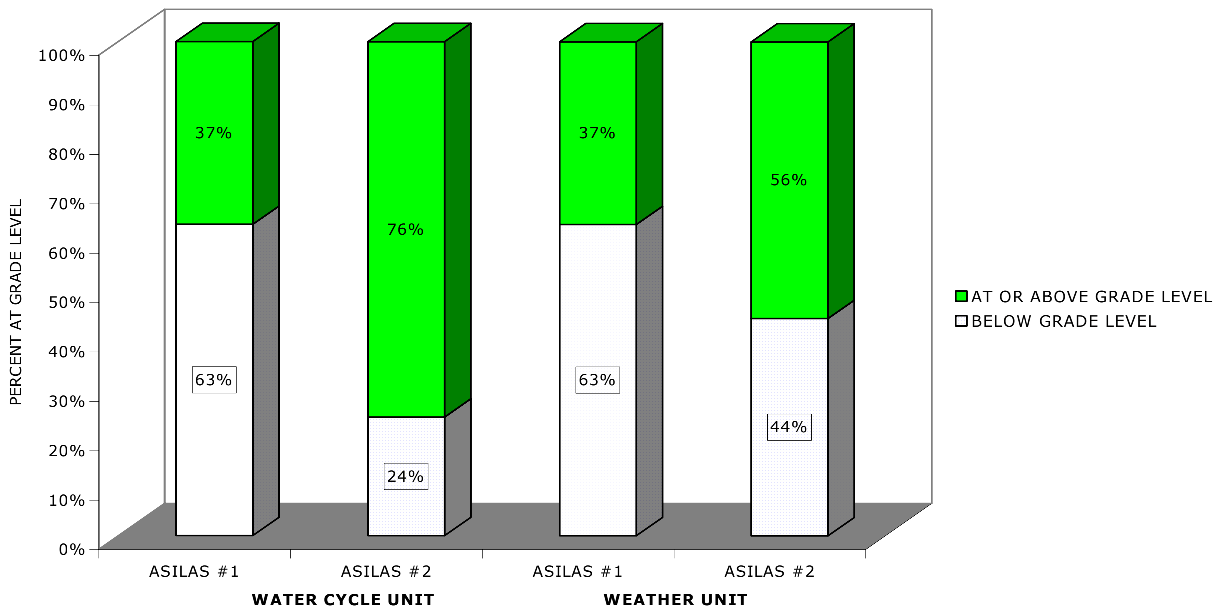

Figure 4. 2002-2003 ASILAS Benchmark Scores

At the onset of the Water Cycle unit*,* only about a third of students were considered to be writing at or above grade level. Two months later when the second ASILAS was administered an additional 39% were reaching grade level expectations, taking the total up to the point where more than three fourths of the class was reaching the target.

Though not as dramatic a shift as with the ASILAS in the Water Cycle unit, a significant number of students managed to reach the benchmark score at the end of the Weather unit than when the first ASILAS was administered. Initially 63% of students demonstrated such troubles with the four domains of the ASILAS rubric that their student writing samples were considered to be at the third grade status. Only 37% of student writing samples were deemed to be grade level appropriate. Yet, by the second ASILAS administration a noticeable shift occurred. An additional

19% for a total of 56% of students were writing science texts that accomplished grade level equivalency. A contributing factor to this development was the literacy activities in the service of science concept learning entrenched through out the science unit that enhanced both literacy and science learning.

Discussion and Conclusions

The results from ASILAS clearly demonstrate that students' understandings regarding writing like a scientist matured as they experienced literacy and science instruction at their intersection. When students were asked to exhibit their acquaintance with the scientific inquiry framework, they initially provided partial responses, at times listing incomplete procedures and/or excluding the hypothesis for their experiments. These gaps were filled for many with extensive opportunities during the unit to experience "hands-on" science where literacy activities such as a lab book scaffolded students' acquisition of science concepts. Conversely, having authentic tasks for reading and writing through out the unit in the service of science also enhanced students' abilities to write expository texts.

In both units, students were better able to handle the demands of the writing task and the science concepts that were expected in the writing samples at the conclusion of the units. Students better understood that their writing needed to be organized in a particular manner, had to include descriptive and science related vocabulary terms, needed to have words spelled correctly, appropriately punctuated and grammatically correct sentences.

These results were also visible when considering the number of students that were reaching grade level expectations at the onset and conclusion of the units. Three fourths of students were considered to be reaching the benchmark score of four at the end of the Water Cycle unit compared with the 37% of students who were reaching this goal at the outset. Similarly, approximately an additional 20% of students managed to reach grade level equivalency for a total of 56% at the conclusion of the Weather unit.

Though students made significant progress, some troubles with writing in an expository genre were uncovered. For the students that experienced the most difficulty in formulating an expository text, a portion of them had a "narrative-tendency", though the prompt elicited an informational text. This genre confusion was a consistent trend for those students who fell below grade level across the four writing assessments probed. Instead of listing their materials and procedures, some students narrated a story that included materials and procedures, but were only mentioned at times when their narrative required them and rarely included all, as is called by the rubric. Moreover, the organization of the scientific inquiry framework was often not reported in a logical sequence. For example, the question to be investigated, that was to drive the experiment, was either left out or placed at the end of their writing.

Implications

To be responsive to the cultural and linguistic diversity of students it is imperative to probe what students bring to the learning context. For the work conducted by SIFA, the rich data utilized to record students' understandings was only made possible by going to the source, student work. Students' writing samples and experiences with the assessment procedures both drove the inception of the assessment at the onset and informed the direction the assessment took when it was piloted. This process assured students were being assessed only after they experienced optimal conditions to learn key grade-level appropriate science concepts with literacy as tool to write as scientists do.

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